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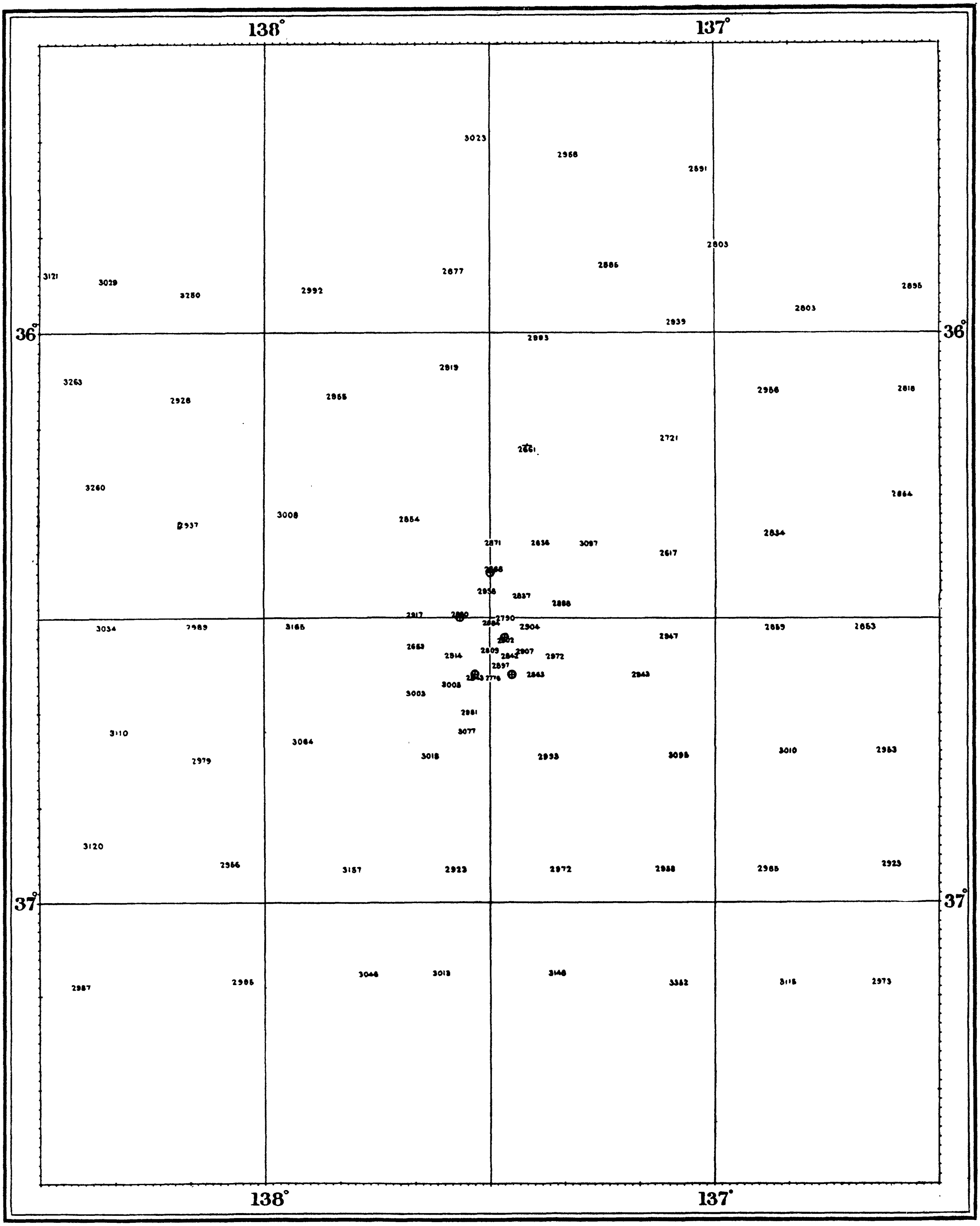
northerly and southerly direction, so that the area of devastation would be an ellipse, the longer axis of which would be from north to south, and the phenomena would resemble those of the Soufrière of St. Vincent rather than of Mont Pelé. There would be danger of the destruction of Camp Jacob and the plantations along the middle slopes of the mountain, but the warnings of an imminent eruption would, perhaps, be heeded by the inhabitants, after the experience of the dwellers upon the slopes of Mont Pelé.

THE DISPROOF OF THE EXISTENCE OF REED OR REDFIELD ROCKS.

BY

G. W. LITTLEHALES.

For fifty years mariners continued to believe, or to be unable to disbelieve, in the existence of dangerous rocks in the Pacific Ocean, in a position about seven hundred miles westward of San Francisco. In 1850 Captain Reed, of the brig *Emma*, reported that he had seen two rocks, measuring from six hundred to nine hundred feet long, and from two hundred and fifty to four hundred feet broad, and having a depth of about three fathoms of water over them, in latitude 37° 24′ north and longitude 137° 22′ west of Greenwich; and in 1851 a report came from the U. S. sloop-of-war *Falmouth* confirming the existence of rocks in this geographical position. Captain Redfield, of the whaler *Susan Abigail*, also reported in 1856 that he had discovered some rocks, with about ten feet of water over them, in a geographical position eleven miles to the northward of the geographical position stated by Captain Reed; and in 1866 rocks were again said to have been seen by Captain Cave, whose report assigned to them a position one mile to the northward and five miles to the eastward of the geographical position agreed upon by the original authorities. Commander Franklin, of the U. S. S. *Mohican*, reported in 1870 that the office of the harbour-master at Honolulu contained records showing that the ships *Kuttosoff* and *Eliza Kimball* had found these rocks, which by that time had come to be known as Reed or Redfield Rocks, and that the latter ship had anchored in five fathoms of water there, and described three of the rocks as extending considerably above the surface of the water.



⊕ *Indicates the different reported positions of Reed or Redfield Rocks.*

DEEP-SEA SOUNDINGS BY THE U. S. SS. RANGER AND WHEELING.

In the meantime the bark *What Cheer* had, in 1858, passed over the locality in which the rocks were reported to exist, and her master stated that he could discover no evidence of their existence, and in 1863 the master of the bark *Live Yankee* had made a similar report; and, although it was well understood, on account of the uncertainty in the reckoning of these vessels and the margin of error inherent in the positions assigned to the rocks, how slight a foundation these reports afforded in disproof of the existence of what had been seen by six apparently reliable and careful ship-masters, and by five of them examined and described, yet they served to stimulate investigation. So that in the years immediately afterwards we find that searches were made by the U. S. sloop-of-war *Kearsarge* in 1870, the U. S. Coast Survey schooner *Marcy* in 1871, the U. S. Coast Survey steamer *Hassler* in 1873, the U. S. S. *Narragansett* in 1875. All of them, however, employed the inconclusive method of proceeding to the reported locality of the rocks and cruising back and forth over the region, with look-outs posted aloft and a certain amount of deep-sea sounding-line hanging over the side of the ship. The four vessels just named must have spent altogether 31 days in this way, and the total distance which they cruised back and forth over the locality is about 2,800 miles.

The reconnaissance made by the *Kearsarge* took place on a beautifully clear day in September. The ship had proceeded from Honolulu, where the chronometers had been verified, and had every facility for determining the accuracy of her position in the field of search; but, although the range of view extended to a radius of ten miles around the ship as she steamed back and forth, visiting in turn each of the positions in which the rocks had been reported, the observed conditions did not reveal the slightest indications of the proximity of shoals or rocks, either by the breaking of the waves or by the presence of birds or fishes.

The examination made by the *Narragansett* took place on a day in June which was most favourable for the work, as the atmosphere was remarkably clear, and there was a heavy swell that would have caused the sea to break in a depth of five or six fathoms; but the lookouts that were posted aloft and on the deck of the vessel during the day's search could discover no indications of the reported danger.

In the search by the *Marcy* the surface conditions were examined in great detail from July 23 to August 5, under favourable circumstances of wind and weather, and with a swell large enough at all times to cause the sea to break in a depth of three fathoms. During this search the distance run by the vessel was one thousand and fifty miles, of which seven hundred and seventy miles were made in daylight, when breakers or any discoloured water should have been visible within at least one mile. A constant lookout was maintained from the masthead, but no breakers were seen, nor any indications of shoal-water, such as the presence of gulls, seals, fish, or kelp. The water was uniformly of a deep blue, and at various places the deep-sea sounding-line was lowered to depths varying from three hundred to eighteen hundred fathoms without touching bottom.

The site of the reported dangers was again and still further examined between the 24th of May and the middle of June, 1873, by the U. S. Coast Survey steamer *Hassler*, but without finding any feature corresponding to Reed or Redfield Rocks. The steamer ran fourteen hundred miles in traversing the region in the vicinity of the reported geographical positions. Lookouts were constantly aloft, but no indications of shoal-water could be discovered.

It is plain that the force of the evidence in disproof of the existence of the Rocks, proceeding from these four searches, rested almost altogether upon the result that the observers did not see them; and it was not until the year 1881 that the first positive evidence was contributed toward the settlement of the question. In August of that year the U. S. S. *Ranger* sounded down to the bottom with pianoforte wire at thirty stations, whose geographical positions were accurately established within the area bounded by the parallels of 37° 20′ and 37° 40′ of north latitude and the meridians of 137° 20′ and 137° 40′ of west longitude. In the light of a mathematical investigation undertaken at the Hydrographic Office to determine the forms and dimensions of isolated submarine formations in the open ocean, these soundings afford positive proof of the absence of Reed or Redfield Rocks from the area which was sounded out.

Isolated formations occupying comparatively limited areas at the bottom can and do occur in deep waters. The minimum radius at the bottom which a dangerous shoal can have must vary directly with the depth of the surrounding sea, but, on the average, in a sea of 2,500 fathoms in depth, it may be stated as ten nautical miles. An interval of 10 miles coupled with an interval of 2 miles and employed systematically in sounding would be sufficient to prove the existence or absence of any formation rising close to the surface. Of all the possible ways in which a 10-mile interval could lie with reference to a submerged peak, that which would be most advantageous for a prompt discovery of its existence is the condition in which one end of the interval is at the bottom of the slope and the other near the apex, and that which would be least advantageous is the condition in which the interval is bisected by the position of the apex. In the latter case there would be nearly equal soundings at both ends, but the soundings at the ends of the adjacent 2-mile intervals would immediately disclose the slopes.

Although the exhaustive examination made by the late Admiral Philip in the U. S. S. *Ranger* was conceded to have disproved the existence of Reed or Redfield Rocks within the area that was searched by him, a doubt remained, owing to the imperfect determination of the geographical position assigned, as to whether the rocks might not be within reasonable limits outside of the field of his inspection, notwithstanding the curious accordance among the reported positions, which only range seven minutes of arc in longitude and seventeen minutes in latitude; and this doubt was strengthened from time to time by the accounts of incoming mariners, who asserted that they had seen these dangers. In 1888 the master of the ship *British Yeoman* reported that he had seen these rocks in passing them; and in 1889 the master of the schooner *Una* reported that he had observed a peaked rock standing four feet above the surface of the sea in latitude 37° 24′ north and longitude 137° 26′ west, saying, "There is not any room for doubt as to this being a rock, but the position may vary a little on account of the sights not being extra good."

The whole question was finally set at rest in the early part of the year 1901, when the U. S. S. *Wheeling*, under instructions prepared by the Hydrographic Office, searched the area marked out by assigning extreme errors of ± 60′ in longitude and ± 40′ in latitude to the average of the reported geographical positions, by sounding down to the bottom of the ocean at intervals so closely spaced that no formation composed of the materials which constitute the earth's crust and shaped with sufficient strength to resist crushing under its own weight and the weight of the superincumbent body of water could rise from a depth of 2,600 to 3,000 fathoms to the surface of the ocean in the interval between any two of the sounding stations.

The area in the immediate vicinity of the reported geographical positions of the danger, bounded by the parallels of 37° 20′ and 37° 40′ of north latitude and the meridians of 137° 20′ and 137° 40′

of west longitude, which was searched by the U. S. S. *Ranger* in 1881, was not entered by the *Wheeling*. The *Ranger* obtained twenty-nine soundings, ranging in depth from 2,776 to 3,097 fathoms, and the *Wheeling* fifty-nine soundings, ranging in depth from 2,850 to 3,352 fathoms. Numerous specimens collected by both vessels indicated that throughout the combined extent of the searches there is a sameness in the characteristics of the bottom soil.

The accompanying chart of the soundings that were taken demonstrates that there is no submarine mountain culminating near the surface of the sea in this region, and shows with equal force that there never were any rocks here nor any shoal upon which a vessel could have anchored.

This is not a locality in which the floating things of the ocean are apt to collect, and it will perhaps ever remain a mystery as to what misleading appearances of the surface of the sea could have given rise to the reports which caused the representation for fifty years in the charts of all the great maritime nations of a dangerous feature which had no real existence.

GEOGRAPHICAL RECORD.

AMERICA.

Colossal Bridges of Utah.—The natural bridges described and illustrated by Mr. W. W. Dyar in the *Century Magazine* for August are believed to be unequalled by any known in other parts of the world. These bridges are near the head of White Cañon, in San Juan County, Utah. The rare phenomenon is here witnessed of erosive forces so balanced against the varying endurance of natural rock cliffs "as to excavate and undermine and leave intact a span of the firmer rock arching over an eroded softer stratum."

Mr. Dyar says that the walls and buttresses of the bridges are composed of pinkish sandstone, streaked here and there with green and orange-coloured moss or lichens. The Caroline bridge measures about 208½ feet from buttress to buttress across the bottom of the cañon. The centre of the arch is 197 feet above the water flowing beneath it. Above the highest point of the arch rises the solid mass of sandstone 125 feet higher to the level floor of the bridge. The causeway is thus 322 feet above the stream, and the floor of the bridge is 127 feet wide.